

U.S. - China Water Resource Management Program

Draft Framework

July 27th, 1998

Exerpts from Remarks by President Bill Clinton in Address on China and the National Interest - October 24, 1997

“Of course, China will choose its own destiny. Yet by working with China and expanding areas of cooperation, dealing forthrightly with our differences, we can advance fundamental American interests and values.”

“...the United States has a profound interest in ensuring that today’s progress does not come at tomorrow’s expense.”

“Last March, when he visited China, Vice President Gore launched a forum with the Chinese on environment and development so that we can work with the China to pursue growth and protect the environment at the same time.”

Background

This effort is intended to support the Vice Presidential/Vice Premier U.S./China Environment and Development Forum; the U.S./China Joint Commission on Scientific and Technological Exchange [headed by Assistant to the President for Science and Technology (Jack Gibbons) and State Councilor for Science and Technology (Song Jian)], the U.S./China Joint Commission on Commerce and Trade led by the Secretary of Commerce, and the development of U.S./China science and technology policy exchanges. There are four committees under the Environment and Development Forum: Energy, Environment, Science and Technology, and Commerce. One critical issue that provides a common thread across all four Forum committees is water resources. Specific next steps resulting from the March 25, 1997 meeting of the forum committees were:

Science: “...the working group agreed to explore expanded cooperation in natural disasters, agriculture, water, climate change, and environmental monitoring.”

Environment: “The bilateral segment of the working group resulted in identification of three areas for further collaboration beyond the activities already underway under the EPA-NEPA MOU...3) joint research on groundwater issues.”

Energy: “Mr. Ye Qing added (to the cooperation proposed by Mr. Curtis) consideration of cooperation on the following topics: small hydropower, “run-of-the-river” technology...”

Commerce: “...and developing a specific focus on cooperative activities related to water and wastewater treatment.”

Problem Statement

The government of China lists the water sector as their top priority for infrastructure development and considers the U.S. the most important of their partners in this area. Global climate variability scenarios generally paint a picture of declining water availability in China in the future while per capita demand will rise. Flooding of river systems displaces millions of people in China on a frequent basis while the geographical distribution of water in China has abundant water in the south and regions of scarcity in the north. In the future China will have to intensify its agricultural production on less land than it currently uses for agriculture and do it in a sustainable manner. China's population will reach 1.6 billion people in 2030, it has limited new arable land, limited water resources, and a need to reduce land and water degradation for future generations. Problems associated with the increased demand for water and energy in the region have been compounded by a drastic decrease in water quality in recent years. The quantity and quality of drinking water from surface and subsurface sources is rapidly diminishing due to contamination by untreated industrial wastes and domestic sewage waters. Leakage from out-dated waste-treatment/disposal systems (e.g., sanitary landfills, ponds and lagoons), and contamination from agricultural fertilizers and pesticides are common. The problem has become so serious that every year, drinking water is unavailable for weeks at a time in some regions, and the number of affected areas is increasing rapidly. Further, the quality of available water is poor by world standards placing serious limitations on economic development, creating major health problems, and laying the seeds of social unrest. It is in the long-term interests of the U.S. to promote environmental protection, local and regional stability, and the application of water resource solutions that yield joint economic benefit.

Program Objectives and Principles

The objective is to develop a coordinated, sustainable water resource management program between the U.S. and China. Four parallel activities are featured in the development of such a bilateral program:

1. Coordinate U.S. and China participants in identification of common problems associated with water resources, both quantity and quality. The short-term focus involves a visit to the United States in April 1998 of a China delegation headed by Mr. Zhang Chunyuan, Vice Minister of Water Resources. A draft cooperative program framework proposal would be discussed as a component of the China delegation visit. The proposal would also be transmitted to other Chinese government organizations under the Forum to engage their participation.
2. Develop and implement a bilateral water resources management workshop as part of the annual meeting of U.S./China Forum on Environment and Development late in 1998. The purpose of the workshop is to compare approaches to water resource management issues then identify and prioritize key areas where ongoing cooperation could inspire changes in water resource management.
3. Develop and implement a joint plan for cooperative water resources management activities. U.S. and China government agencies and other organizations would develop mechanisms to support long-term collaborative efforts and required technical developments. The plan would include routes to fund joint research and water/energy projects to demonstrate application of selected technical approaches. In the U.S., this would include developing an Inter-agency Joint Action Plan.

4. Involve the private sector in joint efforts to transfer technical approaches to actual application in China and U.S. Specifically, engagement of the world financial community (World Bank, Asian Development Bank, etc.) will be required.

Los Alamos National Laboratory, working on behalf of the OSTP and DOE and other federal agencies, will act as the coordinating organization for this effort and will coordinate preparation of the technical program and logistical organization for the bilateral workshop in late 1998.

The program is intended to provide mutual benefit. Benefits to China include:

- Exposure to state-of-the-art technical tools for water resource management;
- Access to commercially available technologies;
- Access to international financing for water management projects;
- New dialog with the U.S. on environmental, technical, policy, and economic issues;
- Improved environmental performance.

Benefits to the U.S. include:

- Dialog with China that can benefit other policy discussions (global climate change, national security, regional stability, balance of trade, etc.);
- Improved water resource management tools for domestic application;
- Improved communication among U.S. agencies with water related missions;
- A coordinated water resources effort that can be reapplied in other regions of U.S. interest (Middle East, Nile Basin, Russia/Formal Soviet Union, Africa, India/Pakistan);
- Development of a Interagency Joint Action Plan to develop required resources;
- An understanding of China's water resource issues will help the U.S. agriculture and U.S. policy makers better understand China's potential to meet its own food and fiber requirements and possible changes in China's agricultural exports and imports;
- Synergy among government agencies on bilateral cooperation.

The long-term objective of this effort is to provide a framework for collaborative efforts on water resource management between the U.S. and China including estimation and acquisition of resources. It is the intent to coordinate existing activities and then expand cooperation in a financially moderate, phased manner. Within the Premier U.S./China Environment and Development Forum there are several topic areas where specific objectives are sought:

Energy

- Deriving the maximum energy value from small hydro power
- Increased energy efficiency in all water resource applications
- Develop infrastructure applications (distribution, treatment)

Environment

- Improved water quality and sustainable resource utilization
- Restoration of polluted resources
- Minimizing the environmental impact of water use for agricultural, energy generation, industrial activity, and domestic use (see note 1)
- Evaluation and comparison of water resource management systems and technology implementation. This includes policy, management and regulatory issues as well as technical approaches.

Science and Technology

- Leverage U.S. federal R&D on resource use and management which has three basic goals: 1) link research to resource management at various temporal and spatial scales; 2) develop the science base and the technologies for determining the mix of resources that

will promote sustainability; and 3) determine how to best sustain and use a given resource across landscapes and the seascape.

- Enhance water resource management tools
- Apply Green Chemistry (upstream process pollution prevention) principles wherever possible
- Integrated observation, modeling and simulation and computing for water resource planning and prediction

Commerce

- Encourage private sector implementation of science and technology solutions
- Enhanced commercial markets for the U.S. and China with worldwide applications
- Develop an economic “Business Plan” as an outcome of the technical workshop to guide implementation of specific projects

Problem Areas for Program Focus

Ongoing discussions between the U.S. and China under the Forum and through existing bilateral activities have raised a number of important water resource management issues for consideration. These are not presented in priority order here but such prioritization should be a critical activity in ongoing U.S./China discussions.

Agriculture

- Irrigation
- Soil conservation
- Improved water use for food production
- Pesticide and other contaminant residues (including fate and transport)

Ecological

- Related water issues
- Wetlands
- Coastal water quality

Industrial Water Use/Waste Water

- Pollution avoidance
- Control
- Remediation
- Policies and regulations for water use and pricing

Domestic Water Use/Waste Water

- Water supply protection/Waste Water
- Control
- Treatment (water supply and waste water)
- Policies and regulations for water use and pricing

Water Basin Management

- Watershed modeling and simulation
- Integrated hydrologic assessment
- Ground water storage capacity
- Ground and surface water connectivity
- Hydrological forecasting on short to seasonal timeframes
- Low head hydro
- Networked hydro power

Flood and Drought Mitigation and Response

- Flood control
- Flood preparedness and response
- Flood plain zoning
- Insurance

Other Problem Areas

- Endangered species protection
- Pest and disease control
- Desalination
- Megacities and water use
- Infrastructure and Distribution Systems

Integrated Approaches to Water Resource Management Problems

An integrated approach to water resources management will be sought that incorporates ecological, economic, political, social, and technological factors including human use and societal benefits. Assessments of this type require teams composed of technical and social scientists. For river basin scale projects, high performance computing is critical not only for the simulation of the hydrologic cycle and contaminant transport but to manage and manipulate the extensive data that are needed for these integrated assessments. Policy and coordination problems often prevent the application of such tools in developing countries.

A simulation approach for regional hydrologic assessment is the technique for performing integrated assessments. Simulation allows scenarios to be developed which includes those factors that are changing. Climatic variability and anthropogenic effects on climate are addressed by simulating global climate and nesting a regional scale atmospheric model. Changes in global climate are reflected in the regional climate in this manner. The regional climate model is coupled to a land surface model that simulates evapotranspiration and runoff, a stream routing model that includes reservoir operations, and a groundwater model to evaluate the effects on groundwater resources. These models including the atmospheric models interact with each other providing feedback between the various components for a more comprehensive evaluation of land use, stream operations, or climatic variability.

Data are needed for model implementation and testing. River basins generally have large amounts of data that are geographically distributed and of mixed quality. Data needed for parameters, initial conditions, and boundary conditions for coupled models like that described in the previous paragraph is extensive. These data are generally not available or must be extracted from sources such as soil maps. Remote sensing technology is one tool that can support both the model development and testing, and in developing countries remote sensing represents the most practical way of obtaining the necessary data. Existing data will be collected and incorporated into the database. Geographical information systems (GIS) is the tool that is best suited for maintaining data in the spatially distributed environment required for model simulation and integrated assessments.

Assessment tools include models of social and economic systems with risk assessment and decision support modules. It is feasible to link these components to the physical model, but the value of this link must be demonstrated.

The intent is to develop an integrated approach to water resource management that incorporates interrelated ecological, social, economic, technological, political factors including human use and societal benefit. Tools include:

- Remote sensing (potentially including classified assets)
- Monitoring, Measurement, and Prediction

- Waste water treatment
- Risk assessment and decision support systems
- Coupling of local and regional assessments and models to global scales. This includes coupling climatic, hydrological, meteorological and river basin management model to aid policy decision making.
- Megacities and urban infrastructure management

Example Workshop Structure and Agenda

One objective of the workshop would be to highlight programs and projects that are currently underway with U.S. and China participation. A second is to determine areas where expanded efforts would yield mutual benefit. The intent is to hold a technical exchange while including important policy and economic considerations that often impede implementation. What follows is an example of an organizing format and an agenda for a bilateral workshop that meets these objectives and paves the way for future collaborations. Other approaches and themes will be discussed both in the U.S. and China. The intent is to engage U.S. and China water resource managers and experts on themes that cross environmental, technical and policy area boundaries. Other potential themes which have been suggested are: Water Quality for Human Consumption, Integrating Water Resource Development for Sustainable Development, Water Management Experiences in the U.S. and China, or Water Resources and Climate Change: Trends, Implications, Science and Policy Imperatives.

Workshop Theme: Management of Water Resources on River Basin Scales. Under this approach participants would explore the issues associated with specific river basins in China and the U.S. (e.g., Huai, Rio Grande, Yellow, Mississippi, Yangtze, or Sacramento). Exchanges prior to the workshop would identify common regional water resource management areas and leverage existing projects working in such regions [examples: Semi-arid regions leveraging the Rio Grande Basin Water Resources project (Los Alamos and multiple agencies) and the Middle East Water Resources Project (Livermore, Los Alamos, Sandia and NREL with DOE sponsorship) or the Large River Basin (Mississippi) effort of GCIP under NOAA]. We would begin by discussing water sources and variations in availability (aquifer/groundwater, surface water, climatic effects, etc.), multiple demands for water utilization (agricultural production, industrial water usage, domestic water usage, power production, etc.), and the types of problems that emerge. These example conditions would provide the basis of smaller group discussions on broader technical and policy approaches to these issues. In small group discussions we would bring together area experts to discuss how a specific approach is 1) currently being applied (commercially available for example), 2) under research and development or 3) considered a need that is not currently being addressed (an R&D gap). Summaries of these small group discussions would then be presented back to the larger group. We would ask the session chairs to integrate these group suggestions into a roadmap for U.S. and China decision-makers. The roadmap would then provide a framework against which potential projects could be proposed and compared. The roadmap could also provide a basis for a bilateral agreement on water resource management programs and projects.

U.S./China Water Resources Management Workshop
Management of Water Resources on River Basin Scales
Potential Workshop Agenda - Fall 1998

Day 1 - PM - Registration and Opening Social Event

Day 2 - AM - Plenary Session

- Welcome Remarks by Vice President/Vice Premier (or ranking representatives) -
 > Goals and Objectives of Workshop
- Remarks by Senior Governmental and Industry Representatives
- Alternating Presentations on Current U.S./China Collaborations
- Presentations on Current Commercial Activities

Day 2 - PM - Plenary Session

- Alternating Presentations on Multiple Water Use Requirements:
 - Agriculture
 - Ecological Impacts
 - Energy Generation
 - Industrial Water Use/Waste Water
 - Domestic Water Use/Waste Water
 - Flood/Drought Mitigation and Response

**Day 2 - PM - Working Sessions on Specific Technical Themes
 Related to Water Use Requirements (co-chaired)**

-Participants will break into groups based on the workshop's three themes:

- Assessment and Prediction
- Infrastructure
- Management

River Basin Management

Discussion Areas	Infrastructure	Management	Assessment/Prediction
Agriculture/Forestry	Storage, distribution, erosion, pollution, quantity and quality (irrigation), crop production	Land use, pollution (non point source). Erosion, distribution, economics, water quality, water quantity	Data sources, data archives, database management, remote sensing, prediction, modeling and simulation
Ecology/Natural Use (Land Use)	Availability of Water, ecosystem health, Quality and quantity of water, natural resource management	Biodiversity, ET, T&E, instream flow requirements, water availability	Data interpretation, satellite imagery, prediction, modeling and simulation
Domestic and Industrial Water Use	Treatment facilities, supply, industrial production, quantity and quality of water	Quantity and Quality of water, human health, cost/price of water	Data sharing systems, sensors, prediction, modeling and simulation
Flood and Drought Planning and Mitigation	Hydropower development, instream flow	Economic and environmental impact of event	Remote sensing, prediction, modeling and simulation

*Issues are energy, environment, commerce, and S&T relative to water use.

Day 2 - PM - Formal Banquet

- U.S./China Keynote Speakers

Day 3 - AM - Plenary Session

- Alternating Presentations on Major River Basin management issues
- Continued Working Sessions on Specific Technical Themes

Day 3 - PM - Continued Working Sessions on Technical Themes

Day 4 - AM - Plenary Session

- Reports from Session Chairs on Working Session Outcomes
- Workshop Close

Day 4 - PM - Session Chairs Meet to Integrate Summaries

- Begin Preparation of Framework Report

Day 5-7 - Site Visits to Selected Industrial or Project Sites

Day 1-4 - Commercial and Technical Exhibits on Display

Timetable:

1. Develop framework and scope for U.S./China Water Resource Management Workshop
- Draft complete by 16 January 1998
2. Review of draft by interagency participants - February 1998
3. Framework transmitted to China agencies - Late March 1998
4. Discussions with China Ministry of Water Resources delegation - April 11-19 1998
5. Formation of joint working group - April 1998
6. Planning meetings in U.S. and China - May through July 1998
7. Bilateral Workshop on Water Resource Management - - early September 1998
8. Development of program implementation plan - Beginning October 1998
9. Briefings to key congressional and agency groups - Beginning April 1998

Deliverables and Metrics

In order to manage the expectations of all participants, it is important to define the deliverables from the workshop and the proposed program and the develop specific metrics to determine progress in execution. While the deliverables and metrics will be developed further as we progress some initial products and progress indicators are as follows:

1. A Draft Framework Document which defines the objectives and benefits of the proposed program, catalogs current cooperative activities and lists potential participants will be developed and circulated to interested parties as a communications tool.
2. A Draft Proposal from the U.S. to involved China agencies will be developed and serve as a point-of-departure for further discussions on program development.
3. In the U.S., an Inter-agency Joint Action Plan will be developed outlining the areas of contribution and expertise of the involved government agencies.

4. The workshop will result in a prioritized list of subject areas where further U.S./China interactions on water resources management are to be encouraged. This will include areas where further research and development is required in the future, areas where financing should be focused, and areas where educational activities would have their greatest impact. This list would be submitted to the Forum on Environment and Development and used by agencies of both governments to guide future expenditures.

5. Agencies responsible for economic development would work closely with technical organizations and financial organizations to develop a "Business Plan" to guide development of investments and exploitation of commercial opportunities.

6. Policy documents for government funding organizations will be developed which document the benefits and expected outcomes of the proposed program.

Definitions:

INFRASTRUCTURE: includes dams, reservoirs, diversions, canals, acequias, hydro power plants, dikes and levees, locks, water and waste water treatment facilities, bridges, cooling facilities etc. We also defined infrastructure as operations, such as use of pesticides and fertilizers, tillage, irrigation, etc.

MANAGEMENT: includes (execution of) interstate compacts, international agreements, federal and state environmental regulations, water rights, policy, economics, zoning, distribution, emergency planning and response, etc.

ASSESSMENT AND PREDICTION: includes data acquisition and management, remote sensing including satellite systems, modeling and simulation, ground and surface water connectivity, integrated hydrologic assessment, contaminant fate and transport, forecasting, economics, quantity and quality, use, etc.

ENERGY: topics include deriving the maximum energy value from small hydro power, increasing energy efficiency in all water resource applications, developing infrastructure applications (distribution, treatment) and, development of "run-of-the-river" technology for energy generation.

ENVIRONMENT: includes joint research on groundwater issues, improved water quality and sustainable resource utilization, restoration of polluted resources, minimizing the environmental impact of water use for agricultural, energy generation, industrial activity, and domestic use, evaluation and comparison of water resource management systems and technology implementation. This includes policy, management and regulatory issues as well as technical approaches.

SCIENCE AND TECHNOLOGY: includes expanded cooperation in natural disasters, agriculture, water, climate change, and environmental monitoring. A goal is to leverage U.S. federal R&D on resource use and management which has three basic goals: 1) link research to resource management at various temporal and spatial scales; 2) develop the science base and the technologies for determining the mix of resources that will promote sustainability; and 3) determine how to best sustain and use a given resource across landscapes and the seascape. Additional topics include enhancing water resource management tools, applying Green Chemistry (upstream process pollution prevention) principles wherever possible and conducting integrated observation, modeling and simulation and computing for water resource planning and prediction.

COMMERCE: The goals are to encourage private sector implementation of science and technology solutions, enhance commercial markets for the U.S. and China with worldwide applications, develop an economic "Business Plan" as an outcome of the technical workshop to guide implementation of specific projects. Specific commercial targets include water and wastewater treatment, irrigation equipment and agricultural products and processes.

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Congressional Briefing List:

Senate - Domenici, Bingaman, Baucus, Boxer, Hagel
- Energy and Water Committee

- Environment and Public Works Committee
 - Energy and Natural Resources
- House - Schiff

- Agriculture Committee
- Science Committee
- Interior Committee
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Appropriations:

- Energy and Water (House and Senate)
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APPENDIX 1 - Inventory of Ongoing U.S./China Water Projects

A key program development strategy is to extend and coordinate programs already underway whenever possible. New program development would be applied where gaps and technical needs are unmet by current efforts. At the workshop we would feature review presentations by leaders (U.S. and China) of ongoing U.S./China water resource projects:

1. Commerce Department

Three major initiatives have been launched by the Administration to deal with U.S.-China environment issues. These include:

- The Joint Commission on Commerce and Trade, which includes a Working Group on Environmental Technologies;
- The Vice President's Forum on Commerce and Development, launched in March 1997, including subdivisions in Energy Policy, Environmental Policy, Science for Sustainable Development, and Commercial Cooperation; and
- The Presidential Summit on the Environment, launched in October, 1997, which includes the categories of Environment and Energy Initiatives, Urban Air Pollution, Rural Electrification, and Renewables.

The Joint Commission on Commerce and Trade's Working Group on Environmental Technologies, which is a joint effort of the Department of Commerce and the Environmental Protection Agency, introduced its first work plan in October 1995, and a second work plan in Oct. 1996. Though a third work plan has not been introduced for 1997/1998.

Another means by which the agency deals with Chinese environmental issues is through training courses on air pollution control technologies that include 4-5 American technical companies and Chinese participants.

2. Environmental Protection Agency projects:

- Pollution Prevention and Control in the Huai River Basin
- Technology Seed Grants to U.S. companies
- Environmental Technology Initiative (ETI) U.S. TIES Program
- Ecological Monitoring Network and Air/Water Monitoring (under U.S./China Urban Air Quality program)

In a recent report, the EPA stated:

Safe drinking water has become the first environmental priority in China. After raw water characteristics were considered, three demonstration sites were initially chosen where various treatment technology configurations would be installed. These systems are aimed at removing high levels of industrial organic contaminants, heavy metals, hardness, iron, nitrate, fluoride, and microbial contaminants from drinking water without generating large amounts of contaminated residual (as can be found with conventional approaches).

Through this project, U.S. EPA will not only serve as a catalyst for expanding the drinking water technology market, but will gain valuable performance data for a variety of drinking water contaminants. In turn, China will gain valuable knowledge regarding the use of effective new technologies as well as improved public health. Four demonstration sites are currently operating.

Government partners include U.S. EPA and USDA, as well as central, provincial, and local Chinese officials. American consulting and equipment vendors include Ecowater, IT Corporation, and the American Commonwealth Management Services Company. Installed technologies include tray and packed tower aeration (for removal of volatile organic

chemicals), multimedia filtration (for removal of various suspended solids), ion exchange (for removal of inorganic ions species like calcium and magnesium ions), and reverse osmosis membranes (for removal of dissolved solids). An international workshop is planned in Beijing for spring, 1999, to disseminate results and encourage further collaboration among drinking water experts.

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3. Department of Agriculture exchanges under Liaison Secretaries for the U.S.-P.R.C. Agricultural Cooperation

Since 1978, over 1000 scientists have participated under the U.S.-PRC Agreement on Agricultural Cooperation in Science and Technology administered by USDA and China's Ministry of Agriculture. The aim of the agreement is to promote U.S. and Chinese agricultural priorities, encourage long-term cooperation in agricultural science and technology, create a positive atmosphere for agricultural trade, and enhance overall relations between the countries.

The exchange program has directly benefited U.S. agriculture through the collection of unique germplasm and biological control agents, exchange of sustainable agricultural techniques, cooperation on forest protection and management, soil and water conservation, and exchange of agricultural statistical data. Long-term research agreements have developed from these short-term scientific exchanges. Three five-year cooperative research agreements on "Biological Control", "Plant Genetics", and Grassland Restoration" were signed in the late 1980's between USDA and the Chinese Academy of Agricultural Sciences and these work plans have been renewed.

The Economic Research Service (ERS) and the National Agricultural Statistics Service (NASS) have been working with a large number of agencies in China to develop a comprehensive system of market intelligence and short term crop forecasting. Commodity and situation outlook reports have been prepared for cotton and rice, and work is underway on reports for pork and corn.

Some of these research programs have been directly related to water resources such as soil and water conservation, irrigation techniques, and development and protection of water resources while others have been indirectly related to water issues such as minimum tillage, biological control agents which have reduced the need for pesticides, and waste management from farms or from food processing plants.

The USDA is also in the process of developing a three week program for 12 employees of the Beijing Drinking Water Source Protection Project Office who are planning and implementing a project entitled "Pollution abatement at Drinking Water Reservoir". The purpose of the project is to reduce pollution in the reservoir through engineering and vegetative measures in the watershed and as such the group is interested in soil erosion controls, watershed management and the use of GIS in land management. The Asian Development Bank is financing this program.

The USDA is in the midst of planning a four year research program on water and agriculture. The quantity and quality of water resources are critically important to agricultural production, food security, farm income and employment in both our countries. Over the next 4 years we propose to study water resource problems in the U.S. and China

through: exchanges of teams of experts, possible exchange of personnel, and conferences on technical topics. Both countries have unique experiences in dealing with water resources issues and it is time to learn from each other, to share experiences, to build links between researchers, and to share technology which can help both nations meet food and fiber requirements of our citizens in a sustainable manner. An understanding of China's water resource issues will help the U.S. agriculture and U.S. policy makers better understand China's potential to meet its own food and fiber requirements and possible changes in China's agricultural exports and imports.

The USDA can provide expertise drawn from the Natural Resource Conservation Service, Forest Service, Agriculture Research Service, Economic Research Service and the Extension Service to address the irrigation, soil conservation, improved water use, and pesticide and other contaminant residues sections. In addition to those areas, other topics to consider might be waterlogging and salinization, watershed management, conjunctive use of surface and groundwater, water pricing, and the soft sciences necessary for extension outreach to farmers. USDA's experience with the extension system which provides research results from ARS laboratories and from universities in a usable form for the farmer and with feedback loops between the farmer, extension agent and researcher needs to be emphasized. In China's system the three parts of the extension system are separated.

USDA's Natural Resource and Conservation Service personnel have been involved in large scale river basin planning and management with other government agencies such as Bureau of Reclamation, Bureau of Indian Affairs, Corps of Engineers, State Agencies, and others. Warren Lee, Director of Watershed and Wetlands from that agency is a member of the CalFed Steering Committee and is also in the "Kitchen Cabinet". In addition Fred Crook with the Economic Research Service is a China specialist and tracks their agricultural production closely. He has lived for extended periods of time in China, is fluent the language, and knows how the government bureaucracy works. ERS and the Foreign Agriculture Service have a considerable interest in the water situation of China and how its quantity, quality and spatial distribution will affect its ability to grow certain crops and thus their import and export of agricultural crops. He can be a valuable asset in planning and carrying out the workshop.

4. Department of Interior Surface Water Hydrology Programs (this ongoing cooperative program should be a cornerstone effort of the program. The Annexes developed provide a strong technical framework for future discussions)
 - Annex 1 - Interchange of Scientific and Technical Information on Hydrology and Analytical Techniques of Water Resources Study
 - Annex 2 - Hydrological Measurement Procedures, Instruments and Equipment
 - Annex 3 - Cooperative Project on Hydrologic Extremes
 - Annex 4 - Cooperative Project on Sediment Transportation
 - Annex 5 - Hydrologic Information and Forecasting (with National Weather Service)
 - Annex 6 - Cold Regions Hydrology
 - Annex 7 - Water Quality
5. National Oceanic and Atmospheric Administration (NOAA) ongoing programs:
 - Marine and Fishery Science and Technology
 - Data and Information Exchange
 - Marine Environmental Sciences
 - Role of Ocean in Global Climate Change
 - Atmospheric Protocol

US China Science and Technology Agreement

The umbrella US – Chinese Science and Technology Agreement, signed in Washington, D.C. on January 31, 1979, currently houses the Marine and Fishery Science and Technology Protocol and the Protocol on Cooperation in Atmospheric Sciences. NOAA Administers two Protocols under the US – China Science and Technology Agreement. In October 1996, Dr. Baker and Rebecca Moser attended the Joint Commission Meeting of the overall Agreement held in Washington, D.C. Dr. Baker highlighted recent accomplishments and new directions for bilateral cooperation in marine and fisheries and atmospheric cooperation. He also spoke to further cooperation to promote sustainable development goals.

US – China Marine and Fisheries Science and Technology Agreement: Marine and Fisheries Protocol

The US and China have cooperated in Marine and Fishery Science and Technology since 1979 under a bilateral protocol jointly managed by the National Oceanic and Atmospheric Administration (NOAA). Other participants in this agreement include NSF, NASA, DOI, and various academic institutes for the United States and the Chinese National Academy of Sciences, the Chinese Academy of Fisheries Sciences, the Ministry of Agriculture, and other agencies in China. This agreement has greatly facilitated data and information exchange, resource leveraging, scientific collaboration, and optimization of national capabilities in marine science and technology.

Activities under the protocol are divided under the following major scientific areas:

1. Oceanographic and Data Information Cooperation – The United States and China continue a steady program of *oceanographic data and information cooperation*. Data exchanged under this panel includes global ocean circulation data, air – sea interaction data (collected from TOGA – COARE and the TOGO – TAO array), tidal area, and other geological and geophysical data.
2. Marine Environmental Services – Marine Environmental Services cooperation includes development of multilateral projects to understand marine pollution and biodiversity in the Yellow Sea Large Marine Ecosystem, diving physiology research to improve diver safety in long submersion dives, ocean research through the State of Hawaii and many other areas.
3. Role of Oceans in Global Climate Change – A program of cooperation in *Role of Oceans in Global Climate Change* coordinates Chinese vessel, laboratory, and personnel support for global oceanographic research experiments, such as TOGA, Coordination of efforts for a South China Sea monsoon experiment and Chinese participation in IRI are potential multilateral projects currently being explored.
4. Living Marine Resources – The bilateral program in Living Marine Resources primarily includes aquaculture, fisheries resource management, ecosystem modeling and data exchange. In 1994, China agreed to provide the United States with living experiments of a commercially valuable strain of shrimp indigenous to the Yellow Sea Region. Under a cooperative program, both sides will jointly research immunology, endocrinology, and genetics of the *Penaeus chinensis* shrimp at the University of Arizona, Texas A&M, and other interested research institutions. Other activities since 1994 include genetic analysis of the Atlantic Bay scallop, technology transfer of Chinese aquacultural practices for commercial applications and outreach education, exploration of new markets of aquaculture in Asia and the United States, and data and information exchange of library material with Chinese labs. In 1997, NOAA library hosted a four month visit of a librarian from the Chinese Academy of Fisheries Science;

while at NOAA, he created a WWW home page containing much information on Chinese fishery resources and activities.

Integrated Coastal Management: The National Ocean Service and the State Oceanic Administration of China have been cooperating for several years in the field of Integrated Coastal Management (ICM). This cooperation has led to a series of exchanges of scientists and coastal management specialists between the two countries, the most recent being May 1997 when an NOS team traveled to Beijing China to jointly design a series of cooperative ICM projects with their Chinese colleagues. Seventeen ICM projects were designed, falling into three main categories: to cooperate in the designing of comprehensive site plans for the three US/China sister sanctuary and reserve sites; to establish and utilize geographic information systems (GIS) and internet technology in the management of coastal protected areas; and to provide guidance in the implementation of a national ICM case study for China. A program document and a web site are currently being developed to provide more information on this cooperative behavior.

Bay scallop research at the Milford Lab: The bay scallop industry in China was spawned by the introduction of brood specimens of the Atlantic scallops from the Milford Lab of NOAA Fisheries' Northeast Fisheries Science Center. The industry has now encountered genetic degradation of the original brood stocks. The Milford Lab has had Chinese scientists working at the lab on joint research on bay scallop genetics and to supply new live specimens to improve the genetic integrity of the brood stocks in China.

Ecosystem Modeling: Development of Ecosystem Model of Jiaozhou Bay – China proposed this project to learn about ecosystem modeling expertise from NOAA Fisheries' Alaska Fisheries Science Center and the University of Washington (Dr. Gallucci). This activity has expanded to involve the University of Georgia and the Institute of Oceanology in Qingdao, China. The model being developed examines effects of physical and chemical environments on resource production, such as clams, scallops, and shrimp. It will be used to evaluate the optimal mix of aquaculture species and improve management for the Bay.

Fisheries Conservation and By – Catch Reduction: Under the United States – China Living Marine Resources Joint Coordination Panel, the two sides have agreed to explore future cooperation in a project that will address a wide range of environmental issues associated with fisheries conservation. Under this project, the United States has proposed sending a team of NOAA experts to China during the spring 1998 to develop a work plan which would identify cooperative research interests and activities in this area.

US – China Marine and Fisheries Science and Technology Agreement: Atmospheric Science Protocol

The US and China have cooperated in the atmospheric sciences since 1979 when the protocol was first signed by the National Oceanic and Atmospheric Administration (NOAA) and the Chinese Meteorological Administration (CMA). The National Weather Service (NWS) is the principal NOAA office responsible for the US aspects of the protocol. Other US participants include the National Science Foundation (NSF), the National Aeronautical and Space Administration (NASA), the Department of Energy (DOE) and various academic institutions.

Joint Working Group meetings are held approximately every two years alternating between China and the United States. CMA Administrator and the Assistant Administrator for Weather Services are the ex officio co-chairs; the US position is currently vacant and therefore the United States has not designated a co-chair. Activities under the Protocol are divided into six major areas as follows:

1. Climate and Monsoon Studies – Continental areas of China exhibit many climatological characteristics similar to North America. CMA scientists routinely work with the National Centers for Environmental Prediction's (NCEP) Climate Prediction Center to improve monthly and seasonal forecasts for central China. The Asiatic monsoon is the dominant weather feature. Over the last several years planning has progressed on a South China Monsoon experiment scheduled for the Summer of 1998.
2. Mesoscale Meteorology – China is affected significantly by mesoscale weather such as typhoons, thunderstorms, and tornadoes. The NWS, NSF, and the National Center for Atmospheric Research (NCAR) have exchanged scientists to further develop China's numerical modeling capability to improve forecasts for these events.
3. Satellite Meteorology – The CMA has embarked on a meteorological satellite program that will eventually include both polar orbiting and geostationary satellites (launched FY-2 GEO in June 1997). NESDIS has routinely hosted visiting CMA scientists who learn techniques such as derivation of upper air wind motion from cloud vectors and the development of vegetation indices appropriate to China. CMA is also interested in learning about the management and station keeping procedures for geostationary orbiting satellites.
4. Atmosphere Chemistry – China has been establishing O₃, CO₂, and CH₄ trace gas monitoring stations in remote parts of the country such as Tibet as part of a Greenhouse Gas emission studies. NASA through the Protocol has been exchanging air samples with CMA for the purpose of calibration.
5. Meteorological Modernization – CMA Computing power has increased by a factor of 103 during the last 10 years. NWS has hosted on an ongoing basis Chinese scientists/programmers learning about NWS numerical weather operations. A year ago, a senior CMA delegation visited NWS facilities throughout the US to learn more about management aspects of a modernized hydrometeorological service. The NWS will also provide training and computer codes as part of CMA's development of a Chinese version of a Doppler weather radar.
6. Training and Participation – The NWS and cooperating agencies through the Atmospheric Science Protocol host scientists, computer programmers and other specialists who learn technical functions that are useful to a broad range of CMA activities in meteorology and hydrology.

NESDIS experts traveled to China in May 1997 to give a series of lectures on the use of multispectral imagery from GOES-8/9 (host: National Satellite Meteorological Center of the China Meteorological Administration); in June 1997 for lecture visit on applications of satellite microwave data (host: National Satellite Meteorological Center of the China Meteorological Administration.) US/China cooperation in the analysis, application and exchange of geostationary satellite data will continue.

In 1997, NESDIS has hosted Chinese scientists: 6-month visit in 1997 of two Chinese scientists from the Ocean University of Qingdao for the research and application of remote sensing data in coastal zones; 6-month visits in 1997 of three Chinese scientists from the Commission for the Integrated Survey of Natural Resources for cooperative research on multi-agency spatial database design, development, and management; 18 month visit in 1997-1998 of Chinese scientist from the National Satellite Meteorological Center of the China Meteorological Administration to work on vegetation indices.

Other Bilateral Activities

Large Marine Ecosystems Projects

Yellow Sea Large Marine Ecosystem: NOAA Fisheries is assisting China in the development of a monitoring and assessment program for the Yellow Sea Large Marine Ecosystem (YSLME). The program will be funded by the Global Environment Facility. The countries that carry out field work would be South Korea, China, and possible, North Korea. NOAA Fisheries has been instrumental in developing the program and will assist with program implementation. The YSLME Program will have 3 modules: 1/ Ecosystem Productivity Module; 2. Living Marine Resources Module; 3/ Pollution Module

Other Large Marine Ecosystem Projects: China has also expressed interest in the development of an LME monitoring and assessment program for the South China Sea LME. In 1996, scientists from China and four other South China Sea countries participated in a South China Sea LME workshop in Manila. The participants endorsed the LME monitoring and assessment approach, and agreed to work together to develop a proposal for GEF funding. It is expected that a GEF Project Development Facility will be developed for the project in 1997.

Hydrology

The PRC Ministry of Water Resources and NWS agreed in August 1994 to develop a prototype flood forecasting system for the Huai River Basin which will then be expanded and applied to the seven major rivers in China as part of a central flood control dispatching system. This project has been compiled in China and we understand the Ministry of Water Resources will receive special recognition by the Chinese central government for successful performance during the 1996 floods, which was based on this cooperation. A second program specific Memorandum of Agreement between the NOAA NWS/Office of Hydrology and the Human Hydro and Power Department has been put on hold due to funding issues within China. This cooperation, if developed, would provide specialized services in river forecasting, training in river forecasting, hydrometeorological forecasting, and software development applied to the rivers in Hunan near Dongting Lake. Finally, additional discussions regarding flood control in Guangdong province (Southern China) and the Yellow River (Northern China) are on hold pending Chinese efforts to locate funding.

GLOBE

In 1995, China agreed to participate in the GLOBE (Global Observations to Benefit the Environment) Program. GLOBE brings together children and young people in the collection and exchange of environmental information to improve appreciation and understanding of the environment. The US company Ameritech will provide financial assistance for China to acquire necessary infrastructure. At least four schools have already been identified by the Chinese government for participation in this program.

Training and Personnel Exchange

NOAA's capacity building efforts regarding China has been active in personnel exchange, collaborative research, and technical training with many Chinese agencies, including the State Oceanic Administration, the Chinese Meteorological Administration, the Chinese Academy of Sciences, the Ministry of Agriculture, the Ministry of Transportation, the Ministry of Water Resources, and others. Recently, budgetary issues have generally required a lowered level of these activities.

U.S. Climate Change Country Study Program

NOAA contributed a total of \$800,000 in 1993 and 1994 to support the U.S. Country Studies Program to assist developing countries in implementing the U.N. Framework Convention on Climate Change. In addition, NOAA/OGP detailed Joseph Huang, NOAA scientist and experienced China Program manager, to the U.S. Country Studies Management Team (CST) to lead the Asia and island nations' country study programs. USCSP is currently supporting 56 countries around the world. One essential component of all country studies is the climate change vulnerability assessments, including physical, social, and economical impacts, and their optional adaptation measures.

China has received the largest USCSP financial support of more than \$2 million in addition to in-kind technical assistance. The study has progressed smoothly and is now focused on climate change action planning. All USCSP activities are closely coupled with China's Agenda 21 for sustainable development.

Integrated Coastal Zone Management – As part of China's Country Study, the USCSP supported a coastal resources vulnerability and adaptation study for China, and recommended that China submit a proposal for a systematic coastal survey to the Global Environment Facility to evaluate the baseline sea level and sea level rise along China's coasts.

International Conference on Greenhouse Gas Mitigation Strategies and Measures – USCSP coordinated a conference for 46 participating nations on Greenhouse Gas Mitigation Strategies and Measures in Beijing in November 1996.

Yixing State Environment S&T Park

China has established a State Environment S&T Park in Yixing. In order to help China gain more information on U.S. environment industrial S&T information and to help U.S. medium and small companies to gain information on China's development needs, the USCSP, EPA, and DOE have supported the development of a Bilateral Environment S&T Information Exchange Center in Washington D.C. and Yixing. There are more than 3000 U.S. environmental companies and about 1500 Chinese ones listed in the data bank. A network link will be established for near real time communication in the future.

Climate Forecasting and Sustainable Development

Future success in our ability to both predict short term climate variability associated with ENSO, and to apply those forecasts to practical problems of public health and safety, agriculture, resource management, and sustainable economic development depends on the dedicated cooperation between the climate research and policy making communities in the Asia-Pacific region. China can play an important role in the development of applications activities for China, and in catalyzing Asian involvement in the regional component of this global effort.

Congratulations are due on the establishment of the National Climate Center in China. We look forward to continued fruitful cooperation with our Chinese colleagues, especially in the assessment of impacts of climate variability and applications of climate forecast information.

Strong appreciation for active Chinese participation in the International Forum on Forecasting El Nino: Launching an International Research Institute (November 1996, Washington D.C.), as well as the historical collaboration between our two countries in the TOGA (Tropical Ocean and Global Atmosphere) Experiment that made possible the advances in our predictive capability.

U.S. – China Forum on Environment and Development

NOAA Administration, Dr. D. James Baker, represents NOAA at the Vice Presidential U.S. – China Forum on Environment and Development and Development (an overarching policy dialogue through which existing and new cooperative activities in sustainable development between the two countries can take place). Plenary and working groups coordinated in this Forum that NOAA addresses include 1. Environmental policy, 2. Science for sustainable development, 3. Sustainable agriculture, fisheries, and food security, and 4. Multilateral environmental policy dialogues. A second meeting of the Forum took place in China in late March 1997. One concrete result of the March meeting was agreement to hold a joint U.S./China Workshop on Natural Disaster Reduction and Mitigation in Beijing in November 1997, in concert with the planned November Joint Commission Meeting. It was also agreed to discuss the potential for further cooperation on water resources issues on the margins of the Joint Commission Meeting.

Selected Multilateral Activities

Fishery relations between the U.S. and China are generally positive, focusing on Pacific fisheries of mutual interest such as Alaska pollock and salmon. The United States is urging China to join the North Pacific Anadromous Fish Commission and sign/accept recently concluded fishery agreements. A recent U.S. court decision requiring foreign commercial shrimp fleets to employ turtle excluder devices by May 1, 1996, or face an embargo of wild-caught shrimp is a particularly sensitive issue.

Central Bering Sea Pollock Fisheries

China is a signatory and founding member of the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea. Under this Convention, China is required to cooperate on pollock fisheries management, research, observer coverage, data collection, and other provisions required of the parties. China has been sending one scientist each year to participate on the NOAA R/V *Miller Freeman* research cruise on pollock in the Bering Sea. NOAA Fisheries has also conducted an observer training session to train foreign observer trainees, including four Chinese scientists, under the Convention.

North Pacific Marine Science Organization (PICES)

China is a founding member of PICES and participates in all its scientific discussions. NOAA Fisheries scientists and scientists from other U.S. institutions interact with their counterparts from China according to the scientific agenda of PICES.

One PICES project involving NOAA Fisheries with China is an evaluation of the “Ecological Impacts on the Jiaozhou Bay Marine Ecosystem.” The Marine Environmental Quality Committee of PICES has established a Working Group to plan and convene a workshop in Jiaozhou Bay, China, with the goal of taking a first step in harmonizing approaches among Pacific Rim countries in assessing ecological impacts from human activities on marine ecosystems. The workshop will involve scientists from PICES countries (Canada, China, Korea, Russia, Japan, and the U.S. Marine Fisheries Service Northwest Fisheries Science Center) working together to assess contaminant distributions that occur within Jiaozhou Bay and the biological impacts to the benthic invertebrate and vertebrate communities and their food webs. An important outcome of the workshop will be an improved appreciation of the approaches, expertise, and needs used by Pacific Rim countries in assessing marine environmental quality. Although firm dates for this workshop have not been set, it should take place sometime during 1998.

Other Common Memberships in Relevant International Organizations

The United States and China are both members of the IWC, CITES, and ICCAT.

Driftnets

In order to strengthen U.S. enforcement capability regarding the moratorium on large-scale pelagic **driftnet** fishing on the high seas, the United States and China signed a one-year Memorandum of Understanding (MOU) on December 3, 1993, on effective cooperation and implementation of the UN General Assembly resolution calling for the moratorium. The MOU allowed enforcement officials of either country to ride on board high seas driftnet enforcement vessels of the other country, which resulted in three PRC enforcement officials riding on U.S. Coast Guard cutters in the North Pacific in each year 1994, 1995, and 1996. The MOU was renewed on December 20, 1994, and for a second time on December 27, 1996, until December 31, 1998. NMFS provides support for the travel of these Chinese officials to and from the port of embarkation.

Asia Pacific Economic Cooperation (APEC)

The United States and China are member economies of APEC. APEC is a unique forum in that its membership includes People's Republic of China, Chinese Taipei, and Hong Kong. Its focus is on trade liberalization and facilitation and economic cooperation. Within its framework, NOAA has actively sought APEC attention on sustainable development and scientific cooperation. NOAA is most active in the APEC Working Groups on Industrial Science and Technology, Marine Resource Conservation and Fisheries. NOAA is also active in promoting APEC attention to environment and sustainable development through meetings of Environment Ministers and promotion of the three APEC sustainable development initiatives: Sustainability of the Marine Environment; Cleaner Production/Clean Technology; and Sustainable Cities.

6. U.S. Army Corps of Engineers

- Corps of Engineers/Ministry of Water Resources Exchange Protocol

7. U.S. Geological Survey

The USGS has been doing mostly surface water under the State Dept. S & T agreement for about 18 years and have recently expanded the agreement to include ground water, water quality, and subsidence.

USGS' Latest Assessment:

COMPARATIVE GROUND WATER-QUALITY ASSESSMENT OF THE TANGSHAN REGION,
PEOPLE'S REPUBLIC OF CHINA, AND TWO REGIONS OF THE EASTERN AND WESTERN
UNITED STATES

DOMAGALSKI, Joseph, SHEDLOCK, Robert, DAWSON, Barbara (U.S. Geological Survey), HANSEL, Colleen (University of Idaho)

The goals of the National Water Quality Assessment (NAWQA) Program of the U.S. Geological Survey (USGS) are to assess the status of and trends in the nation's surface and ground water quality. NAWQA ground water assessment are of three types

representing different spatial scales: study unit surveys, land-use studies, and flow-path studies. Study unit surveys are made by randomly selecting wells that penetrate a regionally extensive aquifer; land-use studies target ground-water quality beneath specific land uses within a regionally extensive aquifer; and flow-path studies are designed to answer questions on ground water and surface water interactions. Because of the success of these studies in the United States, the Ministry of Water Resources of the People's Republic of China (PRC), the Tangshan Water Resources Bureau (PRC), and the Haihe River Water Conservancy Commission (PRC) invited the USGS to use these techniques in a cooperative study of agricultural nonpoint source pollution for an aquifer system located in the north China plain, near the city of Tangshan. Elements of a study unit survey, land-use study, and flow path study were included in the study design, and the results from China are compared with results from the Sacramento and San Joaquin Valleys of California, and from the Delmarva Peninsula of Delaware, Maryland and Virginia. The most serious water quality problem for the Tangshan aquifer system is elevated nitrate concentrations. The median nitrate concentrations of the surficial Tangshan aquifer, the eastern San Joaquin Valley, and the Delmarva Peninsula are statistically similar, between 5 to 7 mg/L as N. Median nitrate concentration for the lower Sacramento Valley is less than these other regions (1.5 mg/L as N). However, nitrate in the Tangshan aquifer system has the highest concentrations (up to 150 mg/L as N) and the greatest amount of variability. Analyses of stable isotopes of hydrogen and oxygen were used to determine the extent of surface water recharge, and potential nitrate transport, to the Tangshan aquifer. Although useful in the Sacramento Valley in determining the extent of ground water recharge from major rivers, the isotopic signatures of the superficial and deep ground water, and the major rivers, in the Tangshan aquifer system, are too similar to provide clues as to the extent of surface water recharge. Age-dating, using tritium-helium and chlorofluorocarbon analyses of groundwater collected along two flow transects in the Tangshan region, indicates that elevated nitrate concentrations occur in ground water from wells as deep as 120 meters that was recently recharged (1940s or later). Wells drilled to depths at or greater than 150 meters in the same region cannot be dated using the methods of this study.

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Department of Energy

APPENDIX 2 - Private Sector Water Resource Capabilities and Projects

1. CH2M-Hill Water Resource Management Projects

Water Pollution Control/Wastewater Treatment

Design-Build-Own-Operate Wastewater Treatment Facilities Ribeirão Preto, Brazil

In partnership with REK Construtora, CH2M HILL is designing and constructing \$30 million in wastewater collection and treatment facilities for Ribeirão Preto, Brazil, a city of 500,000 people. REK/CH2M HILL will own and operate the facilities for 20 years. This is the first privatized wastewater treatment project in Brazil. Through CH2M HILL's efforts, the Global Environment Fund (GEF) has committed to investing in the Ribeirão Preto project, which will substantially improve the water quality of the city's rivers. Project sponsors have formed a corporation, Serviços Ambientais de Ribeirão Preto S.A. (AMBIENT), to manage the agreement. AMBIENT will contract with each of the sponsors for specific segments of the project. CH2M HILL will be responsible for engineering, with process work done in CH2M HILL's offices in Brazil and the United States. REK will be responsible for construction. CH2M HILL will provide construction management, field engineering, project control, and procurement support services. A newly formed Brazilian company, jointly owned by OMI (a CH2M HILL company) and REK, will provide long-term operations services. OMI will handle operations management.

Deep Tunnel Sewerage System Republic of Singapore

CH2M HILL, in a joint venture with Parsons Brinckerhoff, is serving as project manager for this 9-year project. Responsibilities include management of all phases of the project: feasibility study, design, and construction. In addition, the JV is currently conducting the feasibility study, engineering investigation, and preliminary design. The Deep Tunnel Sewerage System will collect transport, treat and dispose of all sewage flows in the Republic of Singapore. Currently under study, the system will include two large interceptors to carry flows to two new treatment plants. The plants will feature state-of-the-art processes to treat the wastewater generated ultimately by five million or more people. Six large operating treatment plants and numerous small plants will be phased out as the two new plants on reclaimed land will be commissioned.

Institutional Support and Development General Organization for Sanitary Drainage Cairo, Egypt

CH2M HILL, in association with its sister company OMI, provided services to the General Organization for Sanitary Drainage to strengthen the managerial, organization, technical, training, and administrative systems and procedures of the Sewerage Authority. More specifically, we assisted GOSD in developing an effective management structure, formulated a financial system for a transition from a government-supported agency to a cost recoverable "economic utility", implemented a new computerized information system, provided management training and supported an O&M training program, implemented a certification system, instituted an inventory control system, supported development of a new GIS of the GOSD collection system, and helped procure \$5 million worth of parts and equipment to support the institutional development effort.

Wastewater Treatment Plant

Coca-Cola

Amatil/Dunaharaszti Municipality, Hungary

CH2M HILL is the prime contractor for the design, construction and subsequent one year operation of a wastewater treatment facility in Dunaharaszti, Hungary to treat a mixed wastewater stream comprising:

- Bottling and bottle washing wastewaters ($3000 \text{ m}^3 \text{ d}^{-1}$) from Coca-Cola bottling operations.
- Domestic sewage from the town of Dunaharaszti ($1500 \text{ m}^3 \text{ d}^{-1}$).
- Septage waste from the town.

The design incorporates screening, grit removal, flow balancing, septic sludge storage and conditioning, anaerobic/anoxic zones, extended diffused aeration, clarification, sand filtration, disinfection, sludge conditioning and pressing, chemical addition - lime, nitrogen, phosphorus, polymer, iron salts, chlorine, polishing/storage lagoons and standby power generation. The site of the wastewater facility is 3.5 km from the town requiring the construction of twin forced mains and 2 submersible pumping stations along with a potable water supply line. In order to minimise the amount of caustic soda discharged from the bottle washing plant at Coca-Cola, a caustic storage and recycle system has been included on the Coca-Cola Amatil (CCA) site utilising membrane technology.

Masterplan for the Restoration of the Utrata River

Ministry of Environment Protection Natural Resources and Forestry

Warsaw, Poland

The Utrata river is heavily polluted from point and nonpoint source inputs which is currently preventing river water use. A masterplan for improvement of river water quality to Polish Class II standards was developed by CH2M HILL with assistance from local subcontractors. This required appraisal of existing data, environmental sampling, water quality modeling and interpretation of GIS information together with the identification, appraisal and recommendations of remedial options. A strategy for the restoration of the river system was developed in collaboration with the Project Advisory Committee. A masterplan project was undertaken for CH2M HILL UNICO Environmental Services Ltd (CUES), Japan, and was sponsored by the Japan Special Fund.

West Point Wastewater Treatment Plant Expansion

Seattle Metro

Seattle, Washington, United States

CH2M HILL served as the prime consultant for planning, environmental impact assessment, permitting, design engineering, engineering services during construction, and start-up assistance services for expansion and upgrading of the West Point Wastewater Treatment Plant. The project involved expanding and upgrading an existing 125 mgd primary treatment facility to provide secondary treatment for peak flows of up to 440 mgd. The West Point treatment plant is located on the shores of Puget Sound adjacent to Discovery Park, the largest natural park within the City of Seattle. Significant concern was expressed by the local community about the appropriateness of the siting, impacts of construction on the park and local neighborhoods, and the impact of the facility on the natural setting. Final design was nearly complete before the actual siting at West Point was approved. The project was subject to more than 100 permit conditions, the most significant being that the plant must be limited in size to 32 acres, about half the size of facilities of similar capacity. Environmental impacts had to be mitigated with a series of landscape perimeter beams, in-plant landscaping and architecture, beach improvements, noise and odor control, and other improvements so that the plant would be masked to the beach and park users. The goal was to provide a "stealth" treatment plant.

The existing West Point plant is one of the two major wastewater treatment facilities serving metropolitan Seattle. Currently, the plant provides primary treatment and disinfection before its effluent discharges in Puget Sound. Under a mandate from the Washington Department of Ecology and an EPA consent decree, Seattle Metro is expanding the West Point plant to provide secondary treatment capabilities on-line by January 1, 1996. The West Point program is being executed under the joint direction of Seattle Metro and CH2M HILL personnel. CH2M HILL established a design team that had full responsibility for the program's design phase and is providing engineering services during construction. During the design phase, CH2M HILL established an independent program design office with full-time participation of ten primary subconsulting firms and more than 50 specialty firms.

**Regional Water Reclamation Plant
Upper Occoquan Sewage Authority (UOSA)
FairFax County, Virginia, United States**

CH2M HILL has been UOSA's principal consulting engineer for more than 25 years. Beginning in 1971, we planned and designed a 15-mgd water reclamation plant to optimize the use of the area's total water resources now serving 1 million people. Significant features include using advanced technology to treat wastewater to near-drinking-water quality and designing the facility to ensure process reliability. Since startup, the plant's performance has been exceptional., and we continued to provide engineering services for a subsequent expansion to 27 mgd. Currently, we are involved in the planning, design, and construction of an expansion to 54 mgd.

**Water Pollution Abatement Program
Milwaukee Metropolitan Sewerage District
Milwaukee, Wisconsin, United States**

CH2M HILL provided program management services including construction management, community relations and public information, permitting, records control, regulatory agency support, economic studies, and design. Coordinated more than 200 design projects and 320 construction contracts at more than 20 sites and saved the customer \$1 billion by applying an innovative technical approach using deep-rock conveyance tunnels for storm water and combined sewer overflows. Specific services included expanding the Jones Island Treatment Plant from 200 mgd to 330 mgd and expanding the South Shore Treatment Plant from 100 to 200 mgd. In addition, CH2M HILL designed a new dewatering and drying facility capable of producing 200 tons of milorganite per day.

**West Basin Water Reclamation Project
Central and West Basin Municipal Water District
El Segundo, California, United States**

This project recovers water from the discharge of the City of Los Angeles' Hyperion wastewater treatment plant, and provides integrated facilities to provide water reuse for industrial, irrigation, and salt water barrier injection/potable demands. The project has an initial capacity of 20 mgd, with provisions for rapid expansion to a capacity of at least 100 mgd, thus becoming the largest water reclamation project in California. Services provided by CH2M HILL included feasibility and pilot studies; permitting assistance; geohydrology investigations and modeling; surveying and photogrammetry; and preliminary and final design, software development and services during construction for the Water Reclamation Plant (WRP) and a portion of the reclaimed water distribution system. Supplemental project involvement included fast-track design/construction management services for satellite nitrification treatment facilities at Chevron and Mobil refineries.

**Great Swamp Watershed Study
Great Swamp Watershed Advisory Committee
New Jersey Department of Environmental Protection and Energy
New Jersey, United States**

The Great Swamp National Wildlife Refuge in New Jersey covers about 7,000 acres of wetlands, upland forest, and grassland, and has a diversity of plant and wildlife species, including threatened and endangered species. The swamp is an important stopping point for migratory waterfowl, controls flood crests, and enhances downstream water quality. Continued development pressure had led to loss of wetlands, flooding, failing septic systems, and nonpoint-source pollution.

This study focused on the impacts of land use, stormwater and wastewater facilities, regulatory programs, and U.S. Fish and Wildlife Service management practices in the swamp. The study included evaluating the water budget under current and buildout conditions, pollutant budgets and the pollutant removal capacity of the Great Swamp, proposed wastewater treatment plant upgrades, and the effects of the pollutant loads and water budget on the vegetation and ecology of the refuge. CH2M HILL reviewed the most significant regulatory programs affecting the wetlands, wildlife, streams, water quality and flows, and other resources, and made regulatory and management recommendations. CH2M HILL found that nonpoint sources of phosphorus should be the focus of future pollution control strategies in the watershed, and that changes in vegetative cover and evapotranspiration have a potentially large influence on the hydrology of the swamp. Specific recommendations concerned future monitoring and data collection efforts; coordination of and changes to federal, state, and local regulations; and modified land use, stormwater, and refuge management practices.

Water Supply Development/Water Treatment

**Joyce Road Water Treatment Plant
Tauranga, New Zealand.**

CH2M HILL is part of a joint venture with Beca and Stevens to design and construct a 9.5-mgd microfiltration (MF) plant for the City of Tauranga, New Zealand. This will be one of the largest MF facilities in the world and will treat flow from a stream with varying levels of turbidity and color and produce a drinking water supply that will meet and exceed the 1995 New Zealand drinking water regulations targeting control of *Cryptosporidium* and *Giardia* protozoa cysts. This project involved prequalification, pilot testing, design, and construction of a membrane filtration facility. A request to submit prequalifying documents for different types of microfiltration and ultrafiltration equipment applicable to drinking water treatment was issued worldwide. Of the more than 10 responses, three were prequalified (one ultrafiltration and two microfiltration suppliers) and their equipment pilot tested for 3 months. Subsequently, a bid document was prepared allowing each of these three suppliers to compete for the project.

**Lake Major Water Treatment Plant
HaliFax, Nova Scotia, Canada**

CH2M Gore and Storie is now part of two joint ventures in a design-build project to construct the new Lake Major WTP. The plant will treat water from Lake Major at a rate up to 91 ML/d (24 mgd), and discharge the water to the East Region (Dartmouth) distribution system. Major facilities being designed include the new treatment plant (conventional color precipitation process) employing two 2-stage mixing, flocculator/clarifiers, and four multimedia gravity filters; two 4.54-ML (1.2-MG) buried concrete storage reservoirs (for treated water), a high-lift pumping station to discharge water to the Dartmouth distribution system, 1,050-mm (42-in) discharge lines from Lake Major to the new plant and from the plant to the distribution system, and chemical storage and feed facilities.

**Foothills Water Treatment Plant
Denver Water Department
Denver, Colorado, United States**

CH2M HILL has provided continuous services for Denver Water's Foothills Water Treatment facility since 1973, when we designed the original 250-mgd plant (expandable to 500 mgd), a dam that included hydroelectric power generation, and a tunnel. Our services have included planning, program management pilot studies, design, construction management, and startup assistance. [Recently, we](#) evaluated alternative disinfection strategies and developed an implementation strategy that reduced initial capital investment by approximately \$40 million. The study evaluated ozone, chlorine dioxide, and sequential application of various disinfectants to meet Denver Water's current disinfection goals, and provide a planning framework to deal with the potentially more stringent requirements of future regulations. Currently, we are conducting pilot studies to optimize treatment performance at the Foothills plant. These studies will examine coagulation optimization to reduce byproduct precursors, and maximize filter performance. We will also be testing alternative filter medias.

**Water Project 2000
Orlando Utilities Commission
Orlando, Florida, United States**

CH2M HILL is program manager for this \$190 million program that involves the design and construction of three new ozone WTPs, conversion of four existing WTPs to an ozone treatment process, replacement of more than 200 miles of transmission pipeline, and automation of all the plants to provide unmanned, unattended, remote operation of the entire regional system. We are also providing operations manuals for five plants in an electronic format that will be interactive and will eliminate the need for hardcopy manuals. To establish consistency in operations for all the water plants, CH2M HILL is preparing design standards for the entire program.

[The construction packages will be bid as construction management-at-risk, and CH2M HILL will serve as the program manager throughout construction. In addition, one of the construction packages will be delivered through the design-build approach, and CH2M HILL will serve as the program manager. We are also the design-builder for a 1-mgd ozone demonstration plant that will test various ozone injection methods. Data from this demonstration plant will be used to determine the preferred ozone injection techniques used in future projects for the Commission.](#)

**East County Water Supply Management Study
East County Water Management Association
Contra Costa County, California, United States**

[The project is using an Integrated Planning approach to create a common water service plan to be used by water agency managers and policy makers that assures a reliable supply of water for existing and future water users in eastern Contra Costa County. Short-, mid-, and long term water management strategies were developed for water demand and supply, and water treatment and delivery options. Supplies include new surface diversions, conversion of agricultural to urban lands, new storage reservoirs, groundwater development, conjunctive use of surface and groundwater, and reclaimed water. All options are addressed for quantity, quality, reliability, cost, environmental, regulatory, and implementability. A facilitated workshop approach was used to gain consensus throughout the project. The Joint Managers Committee and the Governing Boards of each of the member agencies have agreed on the water supply issues, the critical success factors for the plan, the evaluation criteria to rank the alternatives, and the process to develop alternatives. The plan will provide a set of water supply and infrastructure alternatives that will allow each member agency both regional and individual options.](#)

Albuquerque Water Resource Management Strategy Albuquerque, New Mexico, United States

The City of Albuquerque currently relies exclusively on groundwater to meet customer demands of about 125,000 acre-feet per year. Recent studies show that continued sole reliance on groundwater is not a viable long-term strategy. The purpose of this project was the preparation of the Albuquerque Water Resources Management Strategy (AWRMS). Preparation of the AWRMS entails the identification, description, and analysis of water resources acquisition, development, and management alternatives. The best and most feasible alternatives were integrated to provide a comprehensive strategy for implementing safe, adequate, and sustainable water supply sources for the Albuquerque public water system

A phased approach was used to prepare the AWRMS:

- San Juan-Chama Alternative Actions Analysis—activities (a) estimated preliminary costs of the opportunities to use Albuquerque’s currently available resources—San Juan/Chama project water, effluent reuse, and ground water; (b) assessed water rights and water resources potentially available to Albuquerque; and (c) outlined the legal and institutional framework which controls Albuquerque’s use and acquisition of water resources.
 6. Decision Evaluation—work included City decision makers and key stakeholders in an assessment of Phase 1 results to (a) identify actions for potential early implementation, (b) delineate alternative decisions and uncertainties associated with them, (c) assess the need for and costs to be saved or benefits to be gained by gathering additional information, and (d) formulate the detailed structure of Phase 3.
 7. AWRMS Formulation— (a) collect additional information, (b) analyze optimized ground water development, (c) refine the alternatives analysis and undertake necessary environmental assessments, (d) determine recommended approaches for water supply and water rights acquisitions and their associated costs, and (e) draft the blueprint for implementation and construction—the AWRMS.
 8. AWRMS Adoption—comprised the public process needed to finalize and adopt the AWRMS as a Rank II plan.

Water Resources Management/Environmental Restoration

Environmental Policy and Technology Project Newly Independent States (NIS) of Former Soviet Union

CH2M HILL lead a team of contractors to help the newly independent states of the former Soviet Union solve critical environmental problems. The goal of the Environmental Policy and Technology (EPT) Project is to ensure that economic and social restructuring of the NIS is achieved in an environmentally sound manner. In pursuit of this goal, the project contributes to both immediate and long-term environmental quality improvements while encouraging US private sector participation in the region’s environmental management. Work was performed under two linked contracts: (1) a “Core Contract” funds administrative and technical support offices in four locations; and (2) a “Requirements Contract” governs and funds delivery orders for environmental improvements. Under the Requirements Contract, CH2M HILL and its subcontractors performed a number of activities relevant to water and wastewater services. For example, CH2M HILL and its subcontractors have designed and constructed a new reverse osmosis water treatment plant near Turkmenbashi, Turkmenistan. In a separate project, they installed equipment and upgraded operations at WTPs in Nukus and Urgench, Uzbekistan, serving approximately 400,000 people. Another example included analyzing the water utility for the City of Lviv,

Ukraine, to determine how to bring the water service up to European Union standards within 20 years.

**Central Valley Project Improvement Act
Programmatic Environmental Impact Statement
Central Valley, California, United States**

CH2M HILL is assisting the U.S. Bureau of Reclamation and the U.S. Fish and Wildlife Service in the development of a Programmatic Environmental Impact Statement (PEIS) for the Central Valley Project Improvement Act (CVPIA), signed into law on October 30, 1992. The CVPIA amends the authorization of the Department of Interior's central Valley Project (CVP) to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic uses, and adds fish and wildlife enhancement as a project purpose equal to power generation. The CVPIA identifies a number of specific measures to met these new purposes and sets a broad goal of sustaining natural populations of anadromous fish in California's Central valley at a level of at least twice the average of the 1967 through 1991 levels. The CVPIA also directs the Secretary of the Interior to operate the CVP, and to renew existing CVP water service and repayment contracts, consistent with these purposes, to meet federal trust responsibilities to protect fishery resources of affected Indian tribes, and to meet all requirements of state and federal law.

In order to meet the purposes and goals of the CVPIA and the revised purposes of the CVP, the Department of the Interior has retained CH2M HILL as part of a team to develop policies and programs to modify operations, management, and physical facilities of the CVP, and to renew water service and repayment contracts. This has involved CH2M HILL staff in the development of a broad spectrum of options for complying with the National Environmental Policy Act. This assessment of alternatives has required project personnel to describe existing conditions, and model future conditions that would likely result from the implementation of the identified alternatives, in the areas of surface water hydrology, groundwater hydrology, fish populations, vegetation and wildlife, recreation, economics, and social and other impact areas.

**Central Valley Project Improvement Act
Water Management Plan
Central Valley, California, United States**

CH2M HILL is assisting the U.S. Fish and Wildlife and U. S. Bureau of Reclamation in developing a long-term plan for using water dedicated for fish, wildlife, and habitat restoration under the CVPIA. The intent of the plan is to develop the optimal timing and distribution of water deliveries for fish, wildlife, and habitat restoration for an array of water year types, while minimizing impacts to CVP operations. The long-term water management plan is expected to be incorporated in the Operations Criteria and Plan (OCAP) by which the CVP is operated. The water management plan will to provide direction for delivering water for fish and wildlife purposes as well as other CVP purposes. To develop the plan, CH2M HILL is using Facet, a software modeling environment that links CVP operational and biological models in an iterative manner to assess the effects of different delivery patterns on achieving fish and wildlife goals and on CVP operations. Use of Facet to conduct these model runs has reduced the time required to complete a single iteration through all models from approximately 2 weeks to less than a day.

**CALFED Bay-Delta Water Supply Plan
CALFED
San Francisco Bay Area, California, United States**

CH2M HILL is the lead consultant for a comprehensive program to prepare an integrated resource plan for managing the natural resources afforded by the San Francisco Bay and the Sacramento-San Joaquin Delta Estuary. The program will make use of a wide variety of scientific, technological and decision-making tools to develop long-term solutions to

problems related to water quality, fish and wildlife viability, water supply reliability, and the dependability of the Delta levees and channels during natural disasters. The program consists of 16 state and federal agencies and is administered through indefinite quantities contracts with the US. Bureau of Reclamation and a contract with the California Department of Water Resources. To date, we have completed Phase 1 of the Program, which identified three basic alternatives to provide a long-term solution to the Delta. The program is now in Phase II, where detailed alternatives are being evaluated. This evaluation includes modeling studies, impact analyses, common program development, pre-feasibility studies, 404(b)1 assessment, early project implementation, decision-analysis, selection of a preferred alternative, and EIS/EIR preparation. Multiple workshops, advisory committees, and public forums are being used to respond to stakeholder concerns.

**Snake River Resources Review
U.S. Bureau of Reclamation
Boise, Idaho, United States**

CH2M HILL was part of a team selected by the U.S. Bureau of Reclamation to assist in developing a decision support system for their Snake River Resources Review project. The project assesses the hydrologic, environmental, economic and institutional resources of the Snake River and its tributaries upstream of Brownlee Dam and includes the states of Idaho, Wyoming, and Oregon. Data on potential impacts on these resources from changes in river operations are determined by an integrated series of models. These outcomes then feed into a decision process.

CH2M HILL is assisting in the development of the integrated information environment(IIE) that brings data together to produce an assessment of probable outcomes and constraints that is also fed into the decision process. This IIE allows the highly efficient interaction between independent models irrespective of format. Interim and final outputs are displayed in graphs, tables, maps and GIS formats. A key value of this program is the ability to assess the hydrologic, environmental and institutional impacts of a variety of planning scenarios. Examples include impacts to threatened and endangered species, instream flows, fisheries, recreation, riparian habitats, cultural resources, land use, access, water rights and water delivery contracts. CH2M HILL also is assisting the technical teams in development of resource information, data bases, and assessment models. We are also developing methods whereby a variety of stakeholders can access the decision support system via the internet and other forms of remote access.

**Lake Panasoffkee Water and Nutrient Budget Study
Southwest Florida Water Management District
Tampa, Florida, United States**

In response to Florida's 1987 SWIM Act, the Southwest Florida Water Management District (SWFWMD) ranked Lake Panasoffkee number five on its priority list for restoration and management. Lake Panasoffkee covers approximately 18.2 km², and has a mean depth of about 2 metres. Extensive communities of aquatic plants in the lake provide habitat to support an excellent sport fishery. The Floridan Aquifer has been estimated to contribute a significant fraction of the total water inputs to the lake through springs and seepage from the lake bottom.

CH2M HILL was selected by SWFWMD to evaluate the existing database for Lake Panasoffkee, collect additional data needed to assemble water and nutrient budgets for the lake, and use a water quality model to evaluate potential effects of management alternatives on water quality conditions in the lake. Phase 1 of the project included a compilation of existing information about the lake and its watershed, and creation of a GIS database; a preliminary assessment and ranking of pollutant sources to the lake; preparation of a plan of study for a field sampling program; and preparation of a quality assurance project plan for the field program.

The Phase 1 data summary showed no consistent trends in trophic state parameters in the lake between 1977 and 1990, although some variations in water quality and aquatic plants observed during that period were due to episodic events such as backflooding from the nearby Withlacoochee River. Existing information indicates that groundwater contributes about 80 percent of the annual water inputs to the lake, and the water level in the lake is correlated strongly with groundwater levels. Groundwater nutrient concentrations are relatively low, but because of the large volumetric input, groundwater contributes about 44 percent of the annual nitrogen and phosphorus loadings to Lake Panasoffkee.

**ASR System for Water Supply and Everglades Restoration
South Florida Water Management District
West Palm Beach, Florida, United States**

The South Florida Water Management District is responsible for regional flood control, water supply, environmental (wetlands) enhancement, and water quality protection for all or part of the 16 counties within its jurisdiction in South Florida. As an element of its regional water supply planning process, the District retained CH2M HILL to perform a feasibility evaluation of using a regional aquifer-storage and recovery (ASR) system to augment dry season water supplies to meet urban, agricultural, and natural systems demands. South Florida's highly managed drainage system currently lacks adequate storage mechanisms to efficiently manage the tremendous ranges in water availability from the wet season to the dry season.

CH2M HILL assembled information pertaining to the geologic and hydrogeologic conditions within this 3-county study area, and reviewed geophysical logs from deep injection wells and other deep borings, to assess the probable presence of geologic formations conducive to use for ASR applications on a scale suitable for regional water supply augmentation. After confirming that appropriate formations are likely present, computer modeling simulations were conducted to predict the water supply yields that could be realized by linking ASR well systems with either the primary canal system operated by the District, or with constructed reservoirs to be fed by stormwater backpumping during periods of excess surface water flow to downstream tidal systems. These analyses demonstrated that significant water supply benefits could be realized. The District and the U.S. Army Corps of Engineers are in the process of a cooperative study of the South Florida drainage system in terms of its ability to meet the current needs for water management to support Everglades restoration. Early indications are that ASR technology will likely be a part of the watershed management solution. These regional restoration studies are currently ongoing.

**Stormwater System Master Improvement Plan and Watershed Studies
Metropolitan St. Louis Sewer District
St. Louis, Missouri, United States**

CH2M HILL is part of a multi-consultant team involved in conducting a phased stormwater system master improvement planning (SSMIP) project for the Metropolitan St. Louis Sewer District. Completed during the fall of 1995, Phase 1 involved development of stormwater management goals, objectives and policies; initiating a public involvement/outreach program; preparing a watershed planning framework; and conducting an inventory of existing data. Phase 1 work products included:

- *Watershed Data Assessment Report* which reviewed and evaluated the usefulness of existing data sources within St. Louis, St. Louis County and about 93 other municipalities within the service area.
- *Policy and Standards Report* recommended changes to current District policies and standards for level of service (design event), detention methodology, channel treatment, financing, maintenance, and plan review/inspection, erosion and sediment control, prioritization schemes for capital improvements, buyouts of flood-prone structures, water quality and easements.

- *Watershed Planning Framework Report* provided a workbook of the methods for applying the XP-SWMM version of U.S. EPA's stormwater management model (SWMM) to the various watersheds within the District. This was produced so that each watershed consultant would use a uniform approach to modeling.

Phase 2, involved hydrologic and hydraulic modeling of the 62 km² Gravois Creek watershed using XP-SWMM. Other watershed planning activities are expected to include identifying flooding problems and recommending solutions to those problems that consider downstream effects of those solutions. Phase 3, just underway, will involve modeling the Deer Creek and Maline Creek watersheds which are tributary to the Mississippi River adding about 174 km² of additional watershed.

Total Water Quality Management Plan City of Boise, Idaho, United States

The Total Water Quality Management Plan developed for the City of Boise, Idaho provides strategic guidance for system growth, water quality management, and future NPDES permitting. The plan identified short-term (five- to 10-year) capital improvement needs, defined needed actions to probable future regulatory or water-quality imperatives, and recommended actions to preserve flexibility and local choice in how the City manages its wastewater.

Boise's concerns about its wastewater system centered on the need to maintain a cost-effective system that properly protected the environment. Of significant concern was how to factor the unknowns of the future into current facility planning to ensure that short-term decisions are consistent with long-term needs.

To limit future uncertainties and minimize risk associated with current decisions, Boise with CH2M HILL conceived a program to more fully integrate all pertinent issues into its wastewater facility planning. This program included the following elements:

River monitoring - The purpose of the river monitoring activities was to maintain a vigil on the river ecosystem, both to prevent negative impacts and, if they occur, know why. Activities included detailed biological surveys, habitat assessments, river chemical tests, whole effluent toxicity tests, and extensive review of historical data.

Watershed planning - an integrated water resources plan for 64 miles of the Lower Boise River was initiated. This plan included all parties taking water from or discharging water to that segment of the river. Potential nonpoint pollution sources were included. By working together before a regulatory mandate is in place, the parties created mutually beneficial options, broader in scope but potentially much more cost effective and environmentally beneficial, than would otherwise exist.

Permit planning - All potential permit issues were identified and explored. A detailed strategy was established for the most critical issues. Water-quality models, including Monte Carlo dynamic modeling, and trend analysis were used to help formulate an appropriate strategy for the basin.

Facility planning - The permit planning and integrated watershed activities form the basis for evaluating structural and non-structural alternatives. Some of the alternatives evaluated in addition to conventional treatment include source reduction programs, pollution prevention management strategies, river flow augmentation, natural treatment systems, water exchanges (particularly with irrigation water users), water reclamation and reuse, and alternative discharge points.

Decision analysis - The decision analysis process provided the framework for decision making based on the uncertainties of the future, alternatives (what you can do), and values (what you prefer). The combination of decisions and uncertainties facing Boise resulted in more than a million potential actions. The decision analysis process allowed Boise to quickly and cost effectively evaluate all options and define an optimal strategy. In addition, it ensured a clear understanding of what is important in the decision making process, risks associated with that decision, and the sensitivity of the decision to uncertain future events.

Incorporation of decision analysis allowed Boise maximum opportunity to insure that today's decisions allow appropriate flexibility for tomorrow's uncertainties.

Regional Water Supply and Quality Study Washoe County, Nevada, United States

The Washoe County Regional Water Supply and Quality Study was commissioned to facilitate the regional planning process for water supply, wastewater treatment and disposal, nonpoint source pollution control, flood control and other water-quality programs affecting the Truckee river. The goal of the study was to more effectively manage and protect the region's water resources to benefit all water users in the Truckee Meadows and in downstream areas.

Phase I of the study, completed in January, 1992, provided basic information needed to develop and analyze proposed capital improvements and management actions. The intent of the initial plan was to identify future water management needs, potential water resources, possible structural and nonstructural components of an overall resource management program, and opportunities for improving water quality in the Truckee River.

In Phase II, alternative water supply programs were developed for wastewater management, flood control and nonpoint source pollution control. These programs then were checked for conformity with the Truckee Meadows Regional Plan and the policies developed for study by the Regional Water Board. Potential subregional solutions were defined and compared to regional solutions in order to determine the best overall strategies. The Technical Advisory Committee (TAC) and the study team also identified areas of uncertainty that could be encountered over the planning period. These unknowns were handled in the planning process by analyzing alternative future scenarios and developing a staged implementation plan which can be modified to respond to changing future conditions.

Agricultural Development/Irrigation Water Supply

Tushka Valley Farm Appraisal Study Kingdom Agricultural Development Company Egypt

The Government of Egypt (GOE) is developing several large-scale irrigation projects using water from the Nile River. One of the most impressive projects is the South Valley Project in Southern Egypt, which is planned to irrigate 518,656 acres (500,000 feddans). The main water conveyance system consists of a large pump station at Lake Nasser and a very large canal that transports water to locations near the irrigated lands. This system is under construction and is being provided by the GOE. The GOE strategy is for private enterprise to establish the irrigation application facilities and associated farming infrastructure. Several investors are presently evaluating the potential for individual participation in the South Valley Project.

One of these investors, the Kingdom Agricultural Development Company (KADCO) has commissioned CH2M HILL to assess the engineering and infrastructure needs of a large-scale, state-of-the-art agricultural development. The proposed Tushka Valley Farm will encompass at least 103,731 acres (100,000 feddans) within the South Valley Project. The project site is remote, and the project will have to be self-contained, encompassing housing, roads, electrical distribution, food processing, storage, and fresh-packing facilities, all farm equipment, maintenance equipment and facilities, nurseries and laboratories, and the irrigation delivery and distribution systems. CH2M HILL is also estimating costs and revenues associated with these activities, for use by KADCO's financial analysts.

Water Resources Management in Major Irrigation Systems
USAID and Government of Sri Lanka
Columbo, Sri Lanka

CH2M HILL, for USAID and the Government of Sri Lanka, performed studies and presented recommendations for management of water resources in major irrigation schemes in the dry zone of Sri Lanka. Water management issues, techniques, constraints, and organizations were studied in five major irrigation systems to identify improvements and additional studies. The recommended program focused on training, system maintenance, farm extension work, institutional restructuring, and project organization. The study, which covered approximately 903,000 acres of irrigated land, was conducted with Sri Lanka Irrigation Department personnel.

CH2M HILL tasks include sociological investigations, soils and land classification studies, evaluation of cropping techniques and patterns, evaluation of on-farm irrigation methods and organization structures, analysis of irrigation system operations and organization, development of maintenance programs and organizations, outline of various training programs for all operations and maintenance personnel, and evaluation of specific irrigation projects to detail system and irrigation water delivery efficiencies.

Project staff worked on irrigation projects throughout the dry zone, but concentrated on the Uda Walawe and Gal Oya irrigation schemes. Farmer organization and training recommendations were considered essential. After the project operations and maintenance organization, management, operating budgets, and personnel training were reviewed, water management recommendations were made for improved government organization and budgets with a major emphasis on training staff at all levels.

The goal of the water management project was to improve agricultural production in Sri Lanka. This, in turn, was intended to improve farmer income and utilization of Sri Lanka's resources. Financial and economic analyses showed that the proposed water management project guide was feasible.

Operation, Maintenance, and Training Program
USAID and Mahaweli Authority
Colombo, Sri Lanka

For USAID and the Mahaweli Authority, CH2M HILL provided technical assistance for an operation, maintenance, and training program for System B of the Mahaweli Project. The Government of Sri Lanka has implemented this water resources project, a complex multipurpose undertaking that will increase food production and enhance the local economy through improved irrigation. The Maduru Oya System B Irrigation Project is the largest development in the Mahaweli Program, with a gross land area of 136,000 hectares. Until recently, this land was jungle, but new settlements are being developed as part of the Mahaweli Program. These new settlements will include extensive irrigation systems. Because of its immense size, the System B irrigation complex will require considerable professional operation and maintenance skills to keep it functioning. The 25,500 farmers who will settle in System B (Left Bank) have limited experience in irrigated agriculture. CH2M HILL, working with local agencies in Sri Lanka, has developed an operation, maintenance, and training plan. The plan is being directed at the farmer's organizations, which are being established as part of the Mahaweli Project, and at personnel from the Mahaweli Economic Agency, which is the local government agency responsible for operating and maintaining the irrigation system. A monitoring program has been developed to assist in evaluating the performance of the system.

Water Conservation and Transfer Program
Imperial Irrigation District
Imperial Valley, California, United States

CH2M HILL provided technical support in connection with Imperial Irrigation District's (IID) water conservation and transfer program in association with the Metropolitan Water

District of Southern California. The program, initiated in 1989, includes 15 projects designed to conserve water in the District's delivery system and on individual farms. CH2M HILL developed a conceptual framework to define existing losses from IID's water supply systems, including 1,675 miles of irrigation canals, and to evaluate the effects of conservation projects, individually and collectively, in reducing those losses. Careful design was required so that water savings in one area were not offset by increased spillage losses in another area. Conservation projects included canal lining, lateral interceptor systems, instrumentation and control systems, on-farm conservation measures, in-line storage, system automation, and subsurface seepage recovery systems. For IID's concrete lining program, CH2M HILL planned and pre-designed the concrete lining for about 65 miles of lateral canals. CH2M HILL staff also assessed the feasibility of collecting seepage from a main canal and pumping it back into the canal. Issues included placement of the seepage collector, conservation potential, and project costs.

**Environmental Impact Report--Modified East Lowline and Trifolium Interceptors
Imperial Irrigation District
Imperial Valley, California, United States**

CH2M HILL prepared an Environmental Impact Report (EIR) for a group of projects related to the Imperial Irrigation District's water conservation program mandated by the State Water Resources Control Board. The Imperial Irrigation District (IID) is in the Imperial Valley. The Imperial Valley, part of the arid Colorado Desert, is of very flat terrain south of the Salton Sea and is intensively farmed.

With implementation of IID's water conservation program, less water would be used for agricultural irrigation and less irrigation drainage water would leave fields within IID and flow into the Salton Sea. Because there is no surface or subsurface flow outlet from the Salton Sea, the only outflow consists of evaporation. Salts carried into the sea by agricultural drainage, desert washes, and creeks are left behind to concentrate.

Thus, salts (including their increased concentrations as a result of less irrigation drainage inflow to dilute them) were among the contaminants of concern in the environmental evaluation. Other chemicals of concern included selenium, boron, other trace elements, and organo-chlorine pesticides. The EIR evaluated habitats and receptors in the project area (including agricultural ecosystems, adjacent native habitats, and the Salton Sea) that might be adversely affected by the construction or operation of the water conservation program structures. In particular, the ecotoxicological focus was on increased concentration of contaminants in the drainage water or increased concentration of salts in the sea. Potential impacts to several special-status species as well as the protected species were evaluated in the assessment.

Consequently, the EIR represented an integration of ecological and ecotoxicological aspects of the proposed project actions in comparison to other alternatives. The EIR illustrates the application of ecological/ecotoxicological risk assessment to non-point source contaminant problems.

**State-of-the-Art Drip Irrigation Development
Potlatch Corporation
Boardman, Oregon, United States**

Because of the reduced timber harvests from public lands throughout the Pacific Northwest, the supply of wood chips used by Potlatch Corporation's paper mill in Lewiston, Idaho, is becoming scarce. Hybrid poplars, fast growing hardwood trees, can be used to supplement dwindling chip supplies and are being grown in the desert near Boardman, Oregon. CH2M HILL designed a fully automated drip irrigation system, on a scale never before undertaken, to precisely deliver filtered, chlorinated, and fertilized water to each tree's root zone, providing maximum tree growth, water conservation, and energy efficiency. This new system will turn arid farmlands into a forest.

Watering the 12 million trees to be planted on Potlatch's 22,000-acre project requires delivery of 200,000 gallons per minute through nearly 500 miles of mainlines, 19,000 miles of tubing, and 24 million drip emitters. New pressure compensating drip emitters, control valve manifolds, and control sequencing equipment had to be developed to handle the pressure differentials in a system of this magnitude. All drip systems are periodically flushed to guard against clogging. But this system fully automates the flushing and reuses the water for surface irrigation, maximizing water conservation. In addition, computerized irrigation scheduling automatically controls pulsed irrigation's to every tree several times a day so that optimum soil moisture is continuously maintained, no matter what the weather. This advanced, efficient irrigation technology enables extensive cultivation of a new crop while providing economic benefits and the best utilization of scarce water resources for the region.

**Dairy Best Management Practices for Nutrient Removal
South Florida Water Management District
Palm Beach, Dade, and Broward Counties, Florida, United States**

Phosphorus has been identified as the limiting nutrient affecting alga blooms within Lake Okeechobee. Consequently, all watershed management planning by the District over the past 10 years has been primarily focused on phosphorus controls. Within the Lower Kissimmee River Valley, and in the Taylor Creek/Nubbin Slough Basin, extensive development of dairy operations occurred during the 1960s and 1970s. Runoff from these dairy operations was identified as the single most important land use contributing to the extremely high phosphorus loads entering Lake Okeechobee from these basins.

CH2M HILL was retained by the District to design dairy BMPs that could reduce phosphorus export from these basins. A variety of alternative management strategies was developed and ultimately, specific designs were prepared for control and treatment of concentrated wastes generated at concentrated feedlots. In addition, fencing strategies were developed. Following the completion of the project for the District, CH2M HILL also assisted several private dairy operations in implementing these BMPs.

**Chongqing Demonstration Zone of Modern Agriculture – Ecological
Environment Protection Experiment Center
Banan, Chongqing**

The development scheme for the demonstration zone in Banan hopes to increase its agricultural production through the use of modernized agriculture (it's main line); full utilization of the natural and geological conditions of the surrounding hills, flatlands if the isle at the river midstream, and Yang-Ze river; realization on the specific topography and geomorphology and the current status of land utilization; and taking of international markets as guidance.